

Introduction to Network Protocols

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Key concepts, classifications, and common examples

1. What Is a Network Protocol?

- **Definition** – A set of rules and conventions that determine how devices exchange data over a network.
- **Purpose** – Guarantees that disparate hardware and software can communicate reliably and efficiently.
- **Analogy** – Like a language with grammar, vocabulary, and pronunciation rules that enable conversation between speakers.

2. Core Characteristics of Protocols

Characteristic	Description	Why It Matters
Syntax	Format of the data (packet structure, headers, footers)	Enables correct parsing of messages.
Semantics	Meaning of each part of the message (e.g., what a flag indicates)	Determines how actions are triggered.
Timing	Order, speed, and synchronization of message exchange	Prevents collisions, ensures flow control.
Reliability	Mechanisms for error detection/correction (checksum, ACK/NACK)	Guarantees data integrity.
Scalability	Ability to work across small LANs to global Internet	Supports growth without redesign.

3. Protocol Stack Model

3.1 OSI Reference Model (7 layers)

Layer	Primary Function	Typical Protocols
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7 – Application	End-user services (email, web)	HTTP, FTP, SMTP
6 – Presentation	Data representation, encryption	TLS, JPEG, ASCII
5 – Session	Manage dialog/control	NetBIOS, SMB
4 – Transport	End-to-end reliability, flow control	TCP, UDP
3 – Network	Routing & logical addressing	IP, ICMP
2 – Data Link	Frame delivery on a physical link	Ethernet, PPP, Wi-Fi (802.11)
1 – Physical	Bits on the medium (copper, fiber, wireless)	Ethernet PHY, Bluetooth radio

3.2 TCP/IP Model (4 layers)

Layer	OSI Equivalent(s)	Main Protocols
Application	5-7	HTTP, DNS, SMTP
Transport	4	TCP, UDP
Internet	3	IPv4, IPv6, ICMP
Link (Network Access)	1-2	Ethernet, Wi-Fi, ARP

Most modern networks are designed using the TCP/IP model; the OSI model remains valuable for teaching and troubleshooting.

4. Major Families of Protocols

Category	Role	Representative Protocols
Routing	Determine optimal path for packets	OSPF, BGP, RIP
Address Resolution	Map logical to physical addresses	ARP (IPv4), NDP (IPv6)
Transport	End-to-end data delivery	TCP (reliable), UDP (unreliable)
Application	Provide services to users	HTTP/HTTPS, FTP, SSH, DNS
Security	Protect data confidentiality & integrity	TLS/SSL, IPsec, SSH
Management	Monitor and configure devices	SNMP, NetFlow, DHCP

5. Example: How a Web Page Loads (Step-by-Step)

1. **Application Layer** – Browser issues an HTTP GET request.

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2. **Transport Layer** – HTTP request is handed to TCP; a three-way handshake (SYN, SYN?